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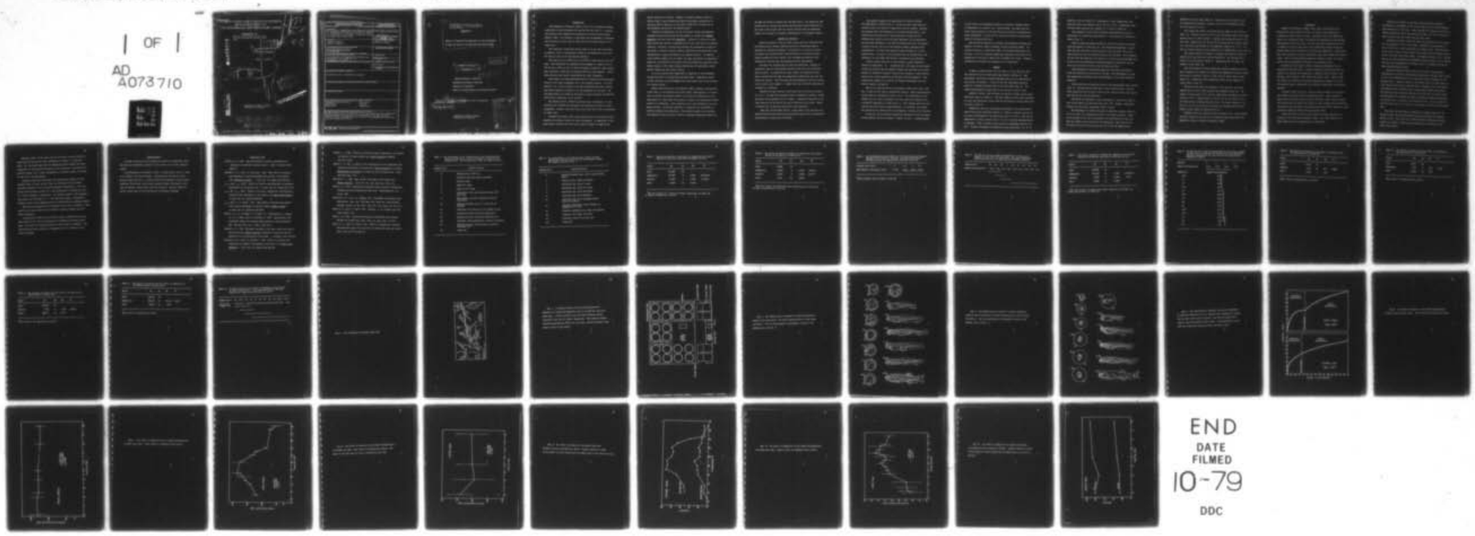

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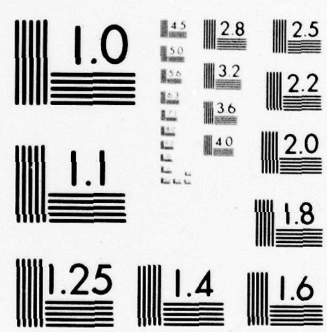

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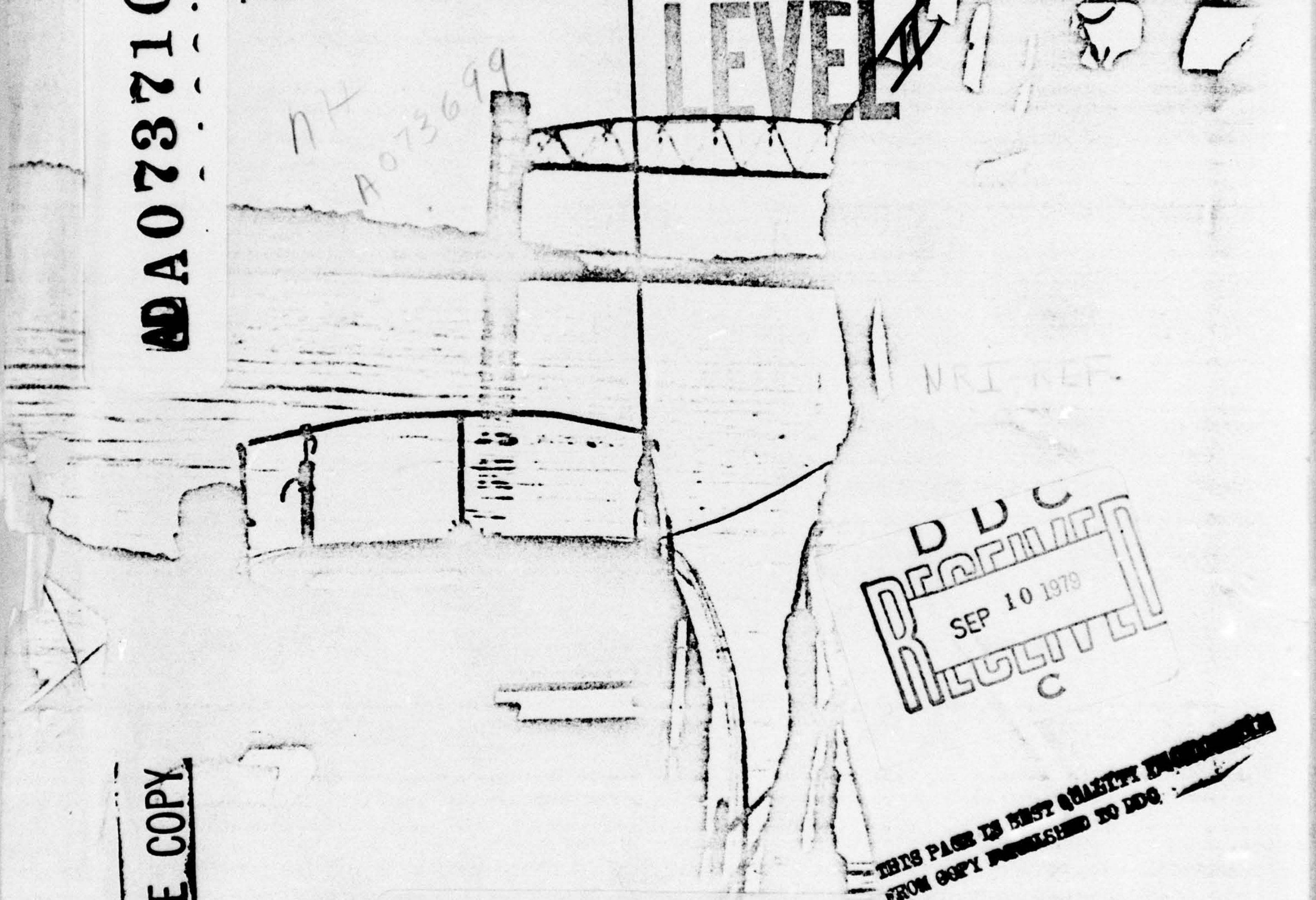
HYDROGRAPHIC AND ECOLOGICAL EFFECTS OF ENLARGEMENT OF THE CHESAPEAKE AND DELAWARE CANAL

Appendix X.

Effects of salinity and temperature on the development of eggs and larvae of striped bass and white perch.



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SEPTEMBER 1973

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER Appendix X	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) Hydrographic and ecological effects of enlargement of C & D Canal: Effects of Salinity and temperature on development of eggs and larvae of striped bass & white perch.	5. TYPE OF REPORT & PERIOD COVERED App. 1971-72
	6. PERFORMING ORG. REPORT NUMBER N.R.I. Ref 73-109
7. AUTHOR(s) Morgan, Raymond P. Rasin, V. James R.	8. CONTRACT OR GRANT NUMBER(s) DACW61-71-C-0062
9. PERFORMING ORGANIZATION NAME AND ADDRESS Natural Resources Institute Chesapeake Biological Lab. U. of Maryland Center for Environmental & Estuarine Studies	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army, Corps of Engineers Philadelphia Dist. Customs House, 2nd & Chestnut St. Philadelphia, Pa. 19106	12. REPORT DATE Sept. 1973
	13. NUMBER OF PAGES 48
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report) Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

For public realse ; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Chesapeake & Delaware Canal
Stripdd bass
White perch
Fish larvae
Salinity
Temperature

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

During spring of 1971 and 1972 white perch and striped bass were studied and salinity-temperature experiments were undertaken on the eggs and larvae. Temperature had a profound effect on the rate of development but white perch were not affeded by salinity.

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Hydrographic and Ecological Effects
of Enlargement of the Chesapeake and
Delaware Canal.

APPENDIX X.

Effects of Salinity and Temperature on the Development

of Eggs and Larvae of Striped Bass and White Perch[1]

12 48p.

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11 Sep 73

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1 Contract No. DACW-61-71-C-0062 Army Corps of Engineers,
Philadelphia District.

14 NRI-Ref. ~~No.~~ 73-109

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INTRODUCTION

The Chesapeake and Delaware Canal (C and D) is an important waterway connecting the upper Chesapeake Bay and Delaware Bay (Fig. 1). Annually, this waterway saves shipping time amounting to several million dollars (Michel, 1966). For instance, a ship going from Philadelphia to Baltimore saves 20 hours of travel time by using the C and D Canal instead of the ocean route.

Net commercial tonnage through the canal is in the tens of millions. In addition, there is considerable traffic in non-commercial craft since the canal is part of the intracoastal waterway.

The canal, prior to 1958, was 76.2 m (250 ft) wide and 8.2 m (27 ft) deep. These dimensions are gradually being changed to a depth of 10.7 m (35 ft) and a width of 137.2 m (450 ft) through a program of canal enlargement initiated in 1958 that is presently 80-90 per cent complete. Larger ships and more ship traffic necessitated the canal enlargement.

Some concern was being expressed about the ecological and hydrographic effects of the canal enlargement due to the dredging program. One study (Cronin et al., 1970) was made in the upper Chesapeake Bay where channels were being deepened to conform to the new dimensions of the canal. The preceding project was funded by the Bureau of Sport Fisheries and Wildlife, United States Department of the Interior.

The present project, funded by the Army Corps of Engineers, is also concerned with studying the ecological and hydrographic effects of canal enlargement. However, the study area is the canal itself and its approaches on either side.

Pritchard and Cronin (1971) have predicted some of the multiple hydrographic and biological effects of canal enlargement. Of importance to the many species utilizing the canal area would be changes in temporal and

spatial patterns of salinity. Changes in salinity patterns could be a direct result of the increased non-tidal net movement, predicted to be from 28.3 m^3/sec (1000 cfs) to 76.5 m^3/sec (2700 cfs), of water out of the Chesapeake Bay and into the Delaware River.

Salinity and temperature are two of the most obvious and important ecological factors influencing the development of striped bass (Morone saxatilis) and white perch (M. americana). Salinity is critical to these fishes which have evolved to spending most of their life cycle in estuarine existence. Basically, salinity may influence the development of eggs and the growth of larvae by osmotic effects, quantitative and qualitative ionic concentrations, oxygen availability, and buoyancy effects. In addition, local salinity regimes may also affect the types and amount of competitors, predators, and diseases of the white perch and striped bass eggs and larvae. Abrupt changes in the normal salinity pattern may be catastrophic, while gradual changes may show subtle effects.

It is also obvious that temperature is important in the development of eggs and larvae of striped bass and white perch. Temperature exerts so much influence on egg development and larval growth that we may consider it a "master factor."

Recent work by Forrester and Alderdice (1966), Alderdice and Forrester (1968, 1971a, b) and Alderdice and Velsen (1971) indicates that it is important to consider the combined effects of salinity and temperature on the development of a fish rather than trying to separate out individually either salinity or temperature. Both, especially as to egg development, are intimately related. We decided, therefore, to undertake our experiments on salinity combined with temperature. This section reports on the information gathered during two years of study on salinity-temperature effects on

the eggs and larvae of striped bass and white perch. The laboratory work concentrated on relating the present and postulated future conditions in the C and D Canal region with the results obtained from the laboratory studies for the purpose of making recommendations on enlargement effects.

METHODS AND MATERIALS

During the spring of 1971 and 1972, white perch were collected from the Patuxent River Estuary, Maryland and held in laboratory tanks at Solomons for artificial spawning. We found that it was best to inject all female fish intramuscularly with 500 IU/250 g of chorionic gonadotrophin immediately after capture. This treatment prevented any yolk reabsorption from the eggs and maintained ovarian development.

The eggs were stripped from the fish and fertilized. Usually, we spawned the eggs into wide-mouthed provision jars that had been filled with tap water. We found that the best results for hatching of white perch occurred when the eggs were exhaustively washed with tap water for about five minutes. After the eggs were water-hardened, they were placed in the selected test chamber. A sample from each artificial spawning was retained as a reference.

Striped bass eggs from the C and D Canal were collected by towing a 0.5 m net. The eggs were transported back to Solomons in coolers, sorted, and placed in the appropriate test chamber. Corrections were made in the final analysis for the age of the egg as collected in the field. Again, a reference set of eggs was retained for each experiment.

Eggs were also obtained from Mr. Joseph Boone of the Department of Natural Resources from fish being artificially spawned for fry production and subsequent stocking out of Maryland.

The schematic design of the apparatus for studying salinity and temperature is shown in Fig. 2. At any one time, four levels of salinity within five levels of temperature could be studied. Salinity was measured with a GM hydrometer or an A/O #TS Refractometer. Temperature was controlled with a Blue M portable cooling coil for refrigeration (usually set at the base temperature for an experiment) and one Braun Thermomix Jr. per tank for heating and water circulation. A plastic bag over the top of each exposure chamber prevented gross contamination. A Silent Giant pumping system furnished air to each exposure bath. The water in each exposure bath was changed after each experiment so that fungal and bacterial transmission was minimized.

Careful records were kept of time exposure to each temperature during the experiments. At determined times, the eggs and any hatched larvae were removed from the exposure chamber and preserved in our modification of Stockard's solution (10 parts pure formalin, 4 parts glacial-acetic acid, 6 parts glycerine, and 80 parts filtered seawater). This preservative allowed us to clearly see internal development since the chorion remained transparent.

Each lot of eggs and larvae was assigned a ranked score (Fig. 3 and Fig. 4) based on the stage of development observed. Major characteristics of each rank are described in Tables 1 and 2. The relationship of the ranking scale to actual development for white perch and striped bass at a specified temperature is shown in Fig. 5. This ranking system was also used for the other areas of experimentation. In addition, each sample was scanned for any abnormalities in development, % hatch, and % survival.

We did not run the salinity-temperature experiment in the same manner as did Alderdice and his co-workers. Rather, we used a ranking system

in this study, which adequately allows us to perform a greater number of experiments in a shorter time. Unfortunately, this sytem does not allow instant analysis of raw data that may be helpful in designing the future experiments. We were able to design the majority of experiments based on the spring 1971 data.

The statistical analysis for salinity and temperature followed the analysis of variance models presented in Sokal and Rohlf (1969). For testing of means in a significant ANOVA, the Student-Newman-Keuls test was used. All of the salinity-temperature experiments were based on the assumptions of the Model I ANOVA since treatments were fixed. Standard randomization techniques were employed in all experiments.

RESULTS

A range of salinity from 0 (0.1-0.5 ppt) to 10 ppt does not alter the development rate of white perch eggs (Table 3 and Fig. 6). Egg development, expressed as ranked development/day, was not influenced by seven levels of salinity. Values for the 1971 experiments agreed to within ± 1 standard deviation (SD) of the 1972 values (Fig. 6). The ranked development/day ranged from 2.44 to 10 ppt to 2.60 at 0 ppt.

Salinity, however, does influence the egg size of white perch; while temperature does not (Table 4). The mean diameter of those eggs incubated at 0 ppt was signficantly larger than the egg diameters at the other salinity levels (Table 5).

Temperature, while not influencing egg diameter, does significantly affect white perch development (Table 3). There is a gradual increase in the rate of development of the white perch from 7 C to 13 C. The rate of development is fairly constant from 11 C to 16 C and then abruptly starts to diminish. There is another lower plateau of development from 20 C to 26 C. Optimum development was observed at four temperatures, 11, 12, 13

(highest), and 16 C (Table 6). Development at these temperatures was more than three times greater than at 20, 25, or 26 C.. Development rates of white perch eggs were very similar at 7 C and 18 C (Table 6).

Both temperature and salinity influence significantly the rate of development of striped bass eggs (Table 7). The influence of salinity is shown in Fig. 8.

There is some discrepancy between the 1971 and 1972 data for striped bass development at 0 ppt (Fig. 8). The ranked development/day for the 1971 data was 5.62 while the 1972 value at 0 ppt was 6.89. All of the other values for 1971 fell within one SD of the 1972 data. We re-examined the 1971 data and found that the value at 17 C for 0 ppt was extremely low. If this value was eliminated and mean development recalculated, the new value was also within one SD of the 1972 data for 0 ppt.

The development of striped bass eggs was 6.89 ranked units/day at 0 ppt and varied from 6.43 to 6.55 at 2-8 ppt. Only development at 0 ppt was significantly different than the development at the other salinities (Table 8).

The percent hatch and survival did not vary significantly with salinity (Fig. 9). The hatch varied from 73% to 2 ppt to 86% at 8 ppt. The survival ranged from 25% at 0 ppt to 34% at 8 ppt. There was very close agreement between the 1971 and 1972 data.

The effect of temperature on the development of striped bass eggs is not as pronounced as in the white perch (Fig. 10). However, temperature effects are still quite significant (Table 7 and 8).

The development of striped bass eggs is relatively constant from 10 C to 13.5 C (Fig. 10), ranging from 5.06 to 5.43 ranked units/day. There is an increase in the rate of development of 124% between 13.5 and 16 C. The rate remains fairly constant in the temperature range from 16 C to 27 C with all of the values except the rate at 22C not significantly

different from each other (Table 8). The rates at 19, 22 and 24 C are not significantly different. However, the rate of development changes by 11.6% from 16 C to 22 C.

The striped bass hatch, as percent per day, peaks at 19 C and 22 C (Fig. 11). Survival from 16 C to 23 C is at an optimum, with a very rapid decline above 23 C (68% survival). Survival was essentially zero at 27 C. The colder temperatures (12, 13, and 16 C) studied had far superior survival than those eggs hatched in the temperature range of 24 - 27 C. We did not observe hatching in the striped bass at temperatures of 10.5 and 11 C.

The osmotic effects of salinity on striped bass eggs was studied by measuring the egg diameter at various salinities. The salinity had no effect on the egg diameter (Table 9). Temperature did not affect egg diameter either (Table 10).

The final analysis for the striped bass salinity-temperature experiments encompasses the effects of salinity and temperature on larval length. Four levels of salinity, from 0 to 8 ppt, did not affect larval length (Table 11). Temperature had a significant effect on the length of the larvae (Table 12 and 13).

The mean larval length was smallest at 13.5 and 16 C, the lowest temperatures for which larval lengths were available (Table 13). The length of larvae grown at 19 C was not significantly different from those larvae at 13.5 C. Larval lengths at 18, 19, 21, 22, 24, and 27 C were not significantly different from each other. The larval lengths at 18, 20, 21.5, 22, 24, 24.5, and 27 C also were not significantly different. Maximal larval length was observed at 21.5 C.

Deformed larvae were observed at 24, 24.5 and 27.0 C. This deformity was most striking in the jaw area. The head of many larvae showed the pugheadness features reported by Mansueti (1958).

DISCUSSION

Alderdice and Forrester (1968, 1971a, 1971b) and Alderdice and Velsen (1971) have studied the effects of salinity and temperature on a variety of Pacific oceanic species. Basically, their work showed that there is an interaction effect of salinity and temperature on the hatching and survival success of an egg. The data from their experiments was used to develop two (and in some cases, three) dimensional models of species success under various conditions of salinity and temperature. These models were then correlated to natural conditions, year-class strength and fishery catch. There was good agreement among the laboratory model, the fishery success and the geographical presence of the spawning stocks.

We have only just begun to obtain comparable information for the striped bass and white perch. Previous research on striped bass has concentrated on salinity and temperature as separate factors (Loeber, 1951; Doroshev, 1970; Albrecht, 1964; Turner and Farley, 1971). Krouse (1968) has studied the survival of juvenile striped bass in relation to levels of dissolved oxygen, temperature, and salinity; essentially a multivariate approach.

As Talbot (1966) points out, salinity does not appear to be critical for striped bass except during the spawning season. Larvae reared in high salinity (25 ppt) had poor survival (Albrecht, 1964); better survival was observed when the larvae were reared in lower salinity water. Generally, our work follows this pattern of good hatch and good larval survival at lower salinities (Albrecht, 1964; Turner and Farley, 1971).

Little work has been done on the effects of either temperature or salinity on the white perch (Mansueti, 1964). Yet, this species is of major importance both economically and ecologically.

Based on our results, we can make some generalized statements concerning the enlargement of the C and D Canal and the salinity-temperature information at this time. These statements are based not only on the limited information that we have gathered to date, but also on the available literature for the striped bass and white perch.

Pritchard and Cronin (1971) have made some predictions on the effects of the enlargement of the C and D Canal. Generally, the Chesapeake sector of the canal is less saline than the Delaware side. There may exist in the canal a higher bottom salinity than surface salinity during periods of low or average fresh water inflow. Pritchard and Cronin (1971), through the use of a one-dimensional time-dependent numerical model, have estimated that the canal enlargement has a minimal effect on salinities during the high spring freshwater inflow.

Information gathered during 1971 and 1972 by Mr. Bernie Gardner (Chesapeake Bay Institute, Johns Hopkins University) indicates that salinity is low in the Chesapeake end of the canal and increases eastward to the Delaware River. Salinity values at the surface and at 8.0 meter depth for five stations (Grove Point, Old Town Point, Chesapeake City, Reedy Point, and Delaware River off Reedy Point) on nine dates follows this pattern. The salinity values during the spring of 1971 and 1972 at Old Town Point and Chesapeake City (roughly the area of intensive striped bass spawning) are between 0.08 - 1.09 ppt at the surface and 0.08 - 1.15 at bottom for Old Town Point and 0.12 - 1.53 ppt at the surface and bottom for Chesapeake City.

The values for the Delaware stations were slightly higher but the maximal values, for the small amount of data we scanned, were approximately 3.5 ppt. There was only a slight difference between the surface and the 8 m salinity, indicating good mixing for the stations in the canal region proper.

Salinity values, in the canal area for two years, are well within the range expected for egg and larval development of striped bass and white perch. The freshwater input from the Susquehanna still remains the factor responsible for the observed salinities in the canal area. Any effects of salinity changes, due to canal enlargement, are extremely small in relation to the flow of the Susquehanna.

Although striped bass development was significantly higher at 0 ppt (actually about 0.5 ppt) than at 2 ppt, the difference of 0.46 ranked units/day probably is not of important biological significance. This difference would probably account for a time differential in hatching of only 2 - 4 hours depending on temperature. The salinity regime in the spawning area varies over the range of 0 - 2 ppt during the spring. Consequently, salinity effects on the spawning success of striped bass are probably minimal.

White perch development was not affected by the level of salinity. Their success in the canal region is not related to salinity changes caused by canal enlargement.

As discussed at length in the results section, temperature has a profound effect on the rate of development for striped bass and white perch eggs. This factor is obviously related to local climatic conditions. The annual and any cyclic variation in temperature is not a function of the canal enlargement.

ACKNOWLEDGMENTS

We wish to thank all of the people who assisted us during this study. The views and information assembled in this report are our sole responsibility.

We acknowledge the assistance of Drs. L. Eugene Cronin, Ted S. Y. Koo, R. K. Johnson, and Joseph O'Connor. Assistance was also given by John Wilson, Douglas Ritchie, Jr., Melvin Beaven, Nona Henderson, Joseph Ustach, Linda Noe, Ruth Wilson, Fran Younger, Bernard Gardner, Mike Reber, Jerry Cox, Tom Johnson, Charles Main, and Terry Peterson. Especial thanks are due Mr. Brooke Gray for his construction of plexiglas equipment.

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Table 1. The relationship of the ranking scale, used in scoring white perch eggs and larvae, to the developmental characteristics of white perch. The developmental stages are shown in Fig. 2.

Ranking Score	Salient Features
0	Unfertilized or dead ova
1	Fertilized egg with single blastomere
2	Two-cell stage
3	Eight-cell stage
4	About 64-cell stage
6	Late morula, very early gastrula stage, with germ ring
8	Early embryo, gastrula encircling yolk and oil globule
10	Two-day-old embryo (18.3 C), just prior to hatching
12	Prolarvae, just after hatch, no pigment in egg
14	One-day-old larvae with more pigmentation
16	Advanced prolarva, with brown pigmented eyes
18	Postlarva, heavy pigmentation, yolk-sac absorption
20	Advanced prolarva, actinotrichia on pectoral and caudal fins
30	Young fish

Table 2. The relationship of the ranking scale, used in scoring striped bass eggs and larvae, to the developmental stages. The stages are shown in Fig. 3.

Ranking Score	Salient Features
0	Non-water-hardened egg, lack of perivitelline space
1	Fertilized egg, single blastomere
2	Fertilized egg, two-cell stage
4	Fertilized egg, eight-cell stage
6	Fertilized egg, early blastoderm
8	Fertilized egg, early embryonic
10	Fertilized egg, fully developed embryo, prior to hatching
12	Prolarva, immediately after hatching, no pigmentation in eyes
14	Prolarva, pigmented eyes, large yolk globule
16	Prolarva, late stage, less yolk
18	Postlarva, little or no yolk left
30	Young fish

Table 3. The two-way analysis of variance for temperature and salinity effects on white perch egg ranked development per day.

Source	SS	df	MS	F[1]
Total	32.1349	35		
Temperature	29.5284	8	3.6911	36.1519***
Salinity	0.1582	3	0.0528	0.5172ns
Error	2.4483	24	0.1021	

[1] For the F values, *** equals very highly significant ($p<0.001$) and ns equals nonsignificant ($p>0.05$).

Table 4. The two-way analysis of variance for temperature and salinity effects on the egg size of white perch

Source	SS	df	MS	F[1]
Total	8.6286	35		
Temperature	0.6323	8	0.0791	0.857ns
Salinity	5.7814	3	1.9272	20.9***
Error	2.215	24	0.0923	

[1]For the F values *** equals very highly significant at $p<0.001$ and ns equals nonsignificant at $p>0.05$.

Table 5. The Student-Newman-Keuls (SNK) test for white perch egg diameters exposed to four levels of salinity. Any means underlined by the same line are not significantly different at $p > 0.05$.

Salinity Level (ppt)	0	2.5	5	10
Egg Diameter[1] (micrometer units)	11.98	11.13	11.03	11.01

[1] Each micrometer unit is equal to 0.072 mm.

Table 6. The SNK test for the ranked development/day of white perch exposed to nine levels of temperature. Any means underlined by the same line are not significantly different at p>0.05.

Temperature-C	26	25	20	7	18	11	12	16	13
Ranked Development/Day	1.07	1.46	1.70	2.42	2.63	3.13	3.29	3.53	3.74

Table 7. The two-way analysis of variance for temperature and salinity effects on striped bass egg ranked development per day.

Source	SS	df	MS	F[1]
Total	46.6590	55		
Temperature	40.6748	13	3.1289	28.4446***
Salinity	1.6943	3	0.5648	5.13*
Error	4.2899	39	0.1100	

[1]For the F values, *** equals very highly significant ($p<0.0001$) and * equals significant at $0.05>p>0.01$.

Table 8. The SNK test for ranked development/day of striped bass exposed to four levels of salinity and fourteen levels of temperature. Any means underlined by the same line are not significantly different at p>0.05.

Salinity	2	4	8	0
Ranked Development/Day	6.43	6.53	6.55	6.89

Temperature	Ranked Development/Day
10.5	5.06
11	5.30
12	5.42
13.5	5.43
16	6.73
27.0	6.84
20	6.91
18	6.95
21	7.01
24.5	7.07
21.5	7.11
19	7.32
24	7.38
22	7.79

Table 9. The analysis of variance for the effect of salinity on the the egg diameter of striped bass

Source	SS	df	MS	F[1]
Total	14.14	16		
Salinity	1.85	13	0.14	0.03ns
Error	12.29	3	4.09	

[1]The F value is nonsignificant at $p>0.05$.

Table 10. The analysis of variance for the effect of temperature on the egg diameter of striped bass.

Source	SS	df	MS	F[1]
Total	14.07	16		
Temperature	3.83	4	0.96	1.13ns
Error	10.24	12	0.85	

[1]The F value is nonsignificant at $p>0.05$.

Table 11. The analysis of variance for the effect of salinity on the larval length of striped bass

Source	SS	df	MS	F[1]
Total	1590.38	44		
Salinity	9.63	4	2.407	0.061ns
Within	1580.75	40	39.52	

[1]The F value is not significant at $p>0.05$.

Table 12. The analysis of variance for the effect of temperature on the larval length of striped bass

Source	SS	df	MS	F[1]
Total	1590.38	44		
Temperature	1181.59	10	118.16	9.83**
Error	408.79	34	12.02	

[1]The F value is significant at $p<0.01$.

Table 13. The SNK analysis for the effect of temperature on the length of larval striped bass. Any means underlined by the same line are not significantly different at $p > 0.05$.

Temperature-C	16	13.5	19	21	27	22	24	18	20	24.5	21.5
Mean Larval Length (mm)	3.44	3.57	4.09	4.29	4.40	4.44	4.62	4.67	4.92	5.09	5.10

Fig. 1. The Chesapeake and Delaware Canal area.

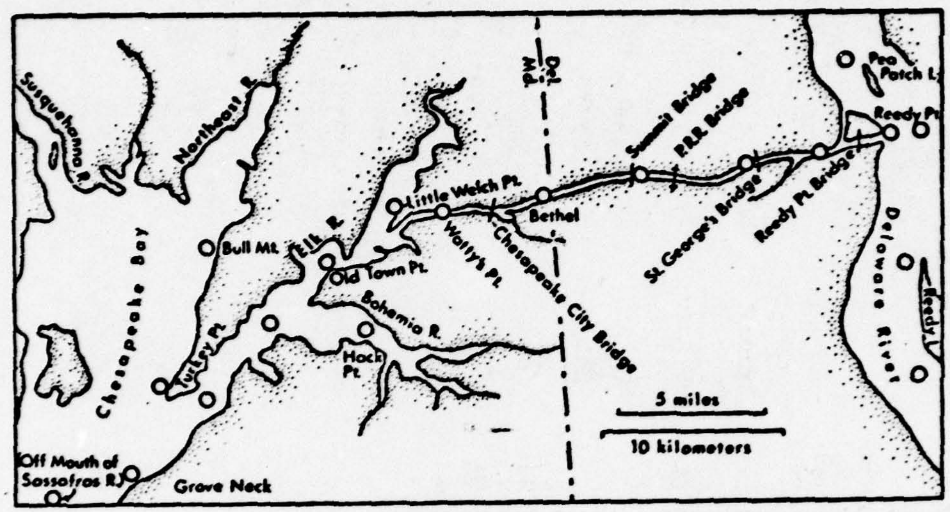

Susquehanna R.
Northeast R.
Chesapeake Bay
Bull Mt.
Elk R.
Turkey Pt.
Off Mouth of Sassafras R.
Grove Neck
Old Town Pt.
Bohemia R.
Hack Pt.
Little Welch Pt.
Welty's Pt.
Chesapeake City Bridge
Bethel
Del.
Md.
Summit Bridge
P.R.R. Bridge
St. George's Bridge
Reedy Pt. Bridge
Pea Patch I.
Reedy Pt.
Reedy I.
Delaware River
5 miles
10 kilometers

Fig. 2. A schematic diagram of the salinity-temperature apparatus for testing developmental rates of striped bass and white perch eggs. A Blue-M portable cooler and Braun immersion heater circulators were used to control temperature. Each exposure chamber contained approximately 5000 ml of test water, thereby ensuring a high ratio of water to egg volume.

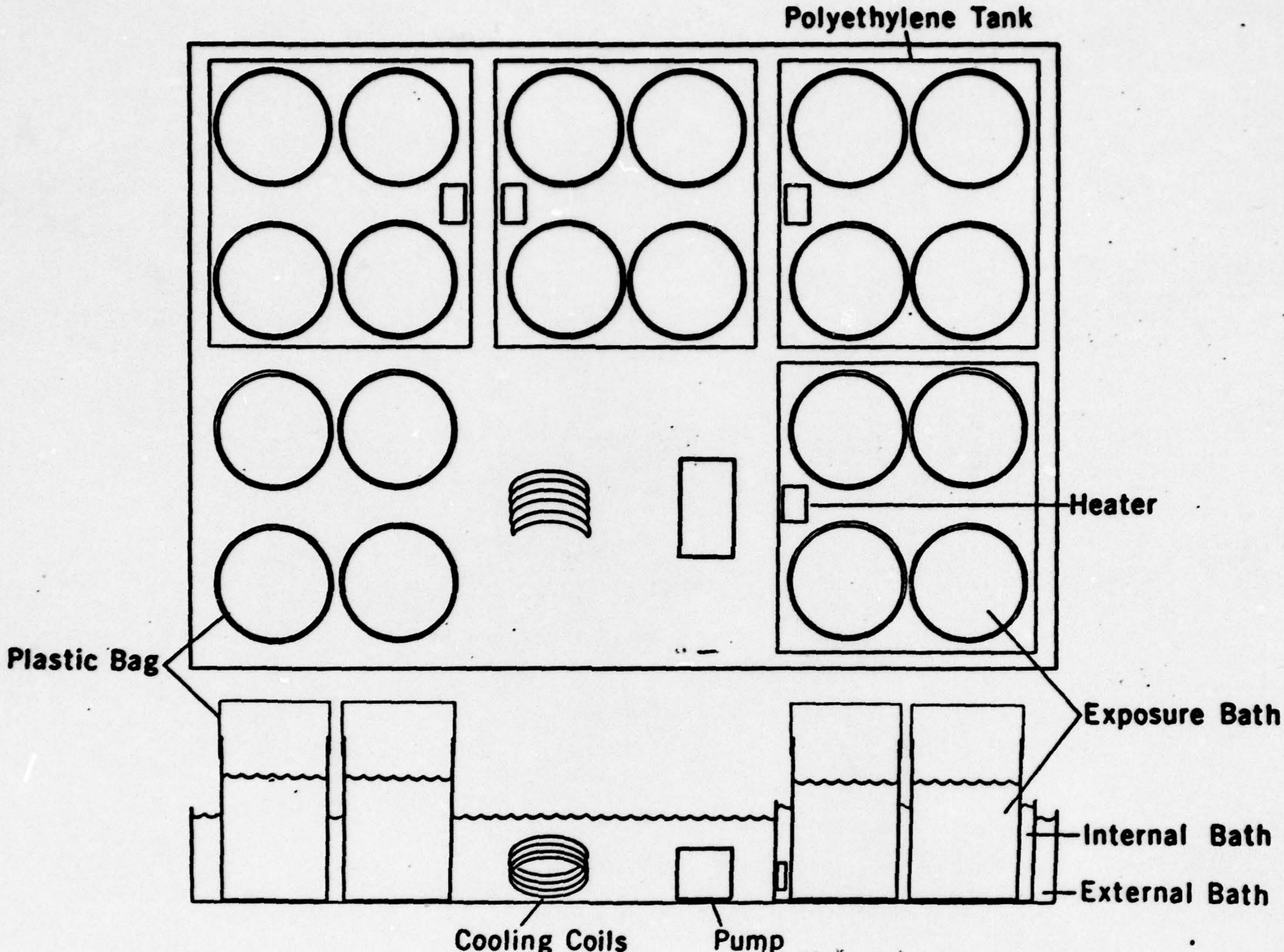

Polyethylene Tank
Heater
Plastic Bag
Exposure Bath
Internal Bath
External Bath
Cooling Coils
Pump

Fig. 3. The ranking score as applied to certain developmental stages of the white perch. For major characteristics of each stage, see Table 1. For the relationship of development in hours to the ranking scale, see Fig. 5.

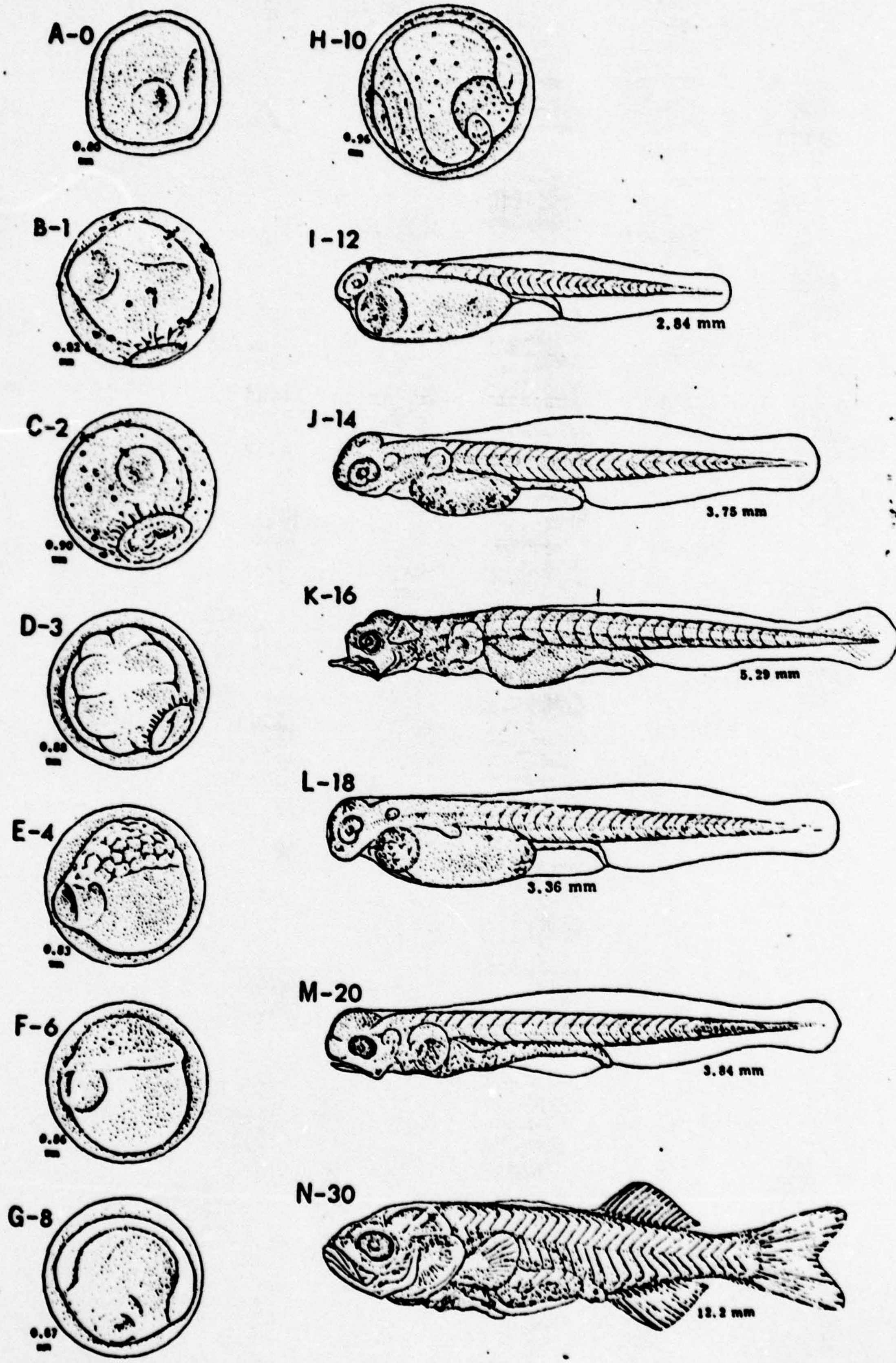

A-0
B-1
C-2
D-3
E-4
F-6
G-8
H-10
I-12
2.84 mm
J-14
3.75 mm
K-16
5.29 mm
L-18
3.36 mm
M-20
3.84 mm
N-30
13.2 mm

Fig. 4. The ranking scale as applied to certain development stages of the striped bass. For major characteristics of each stage, see Table 2. For the relationship of development in hours to the ranking scale, see Fig. 5.

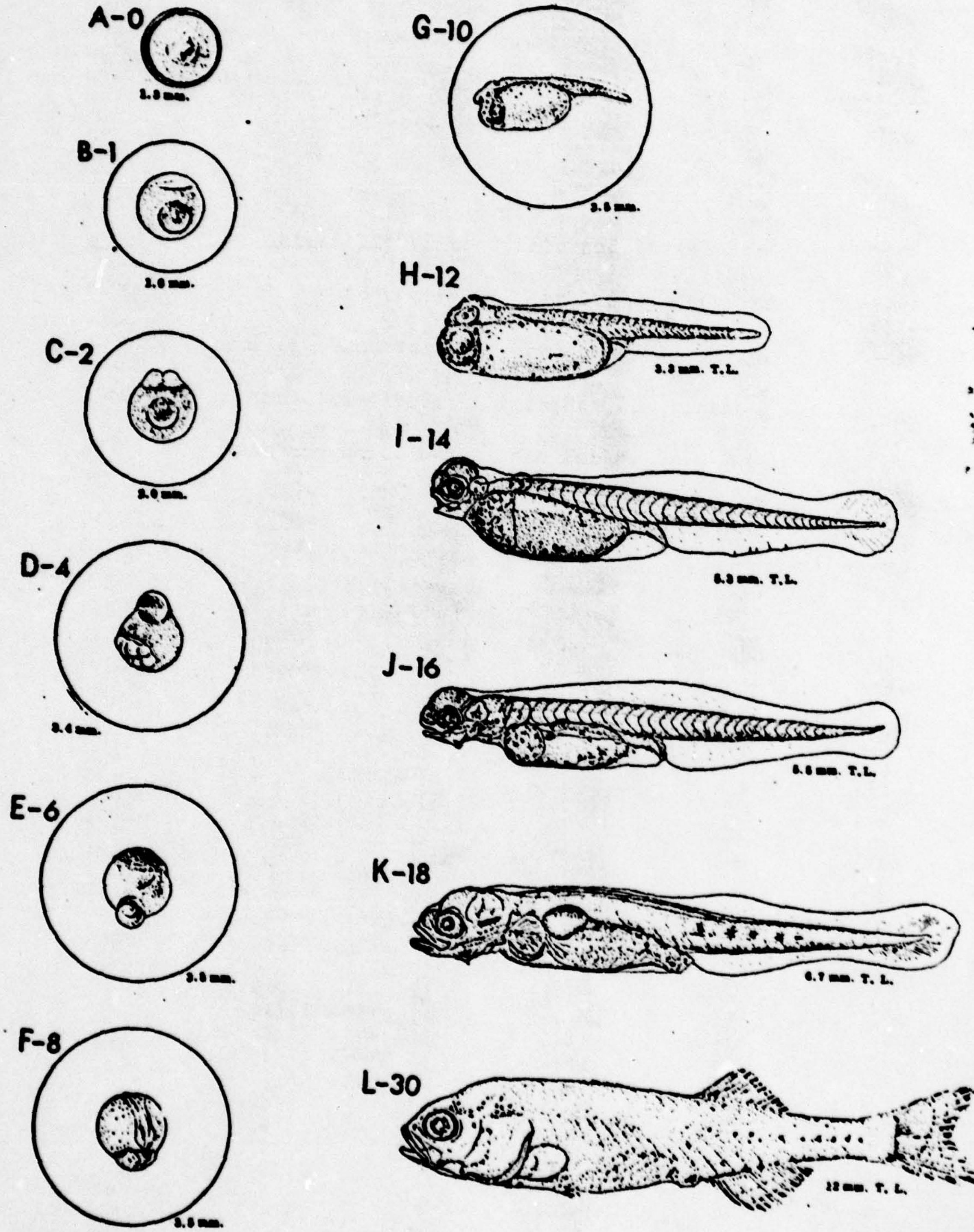
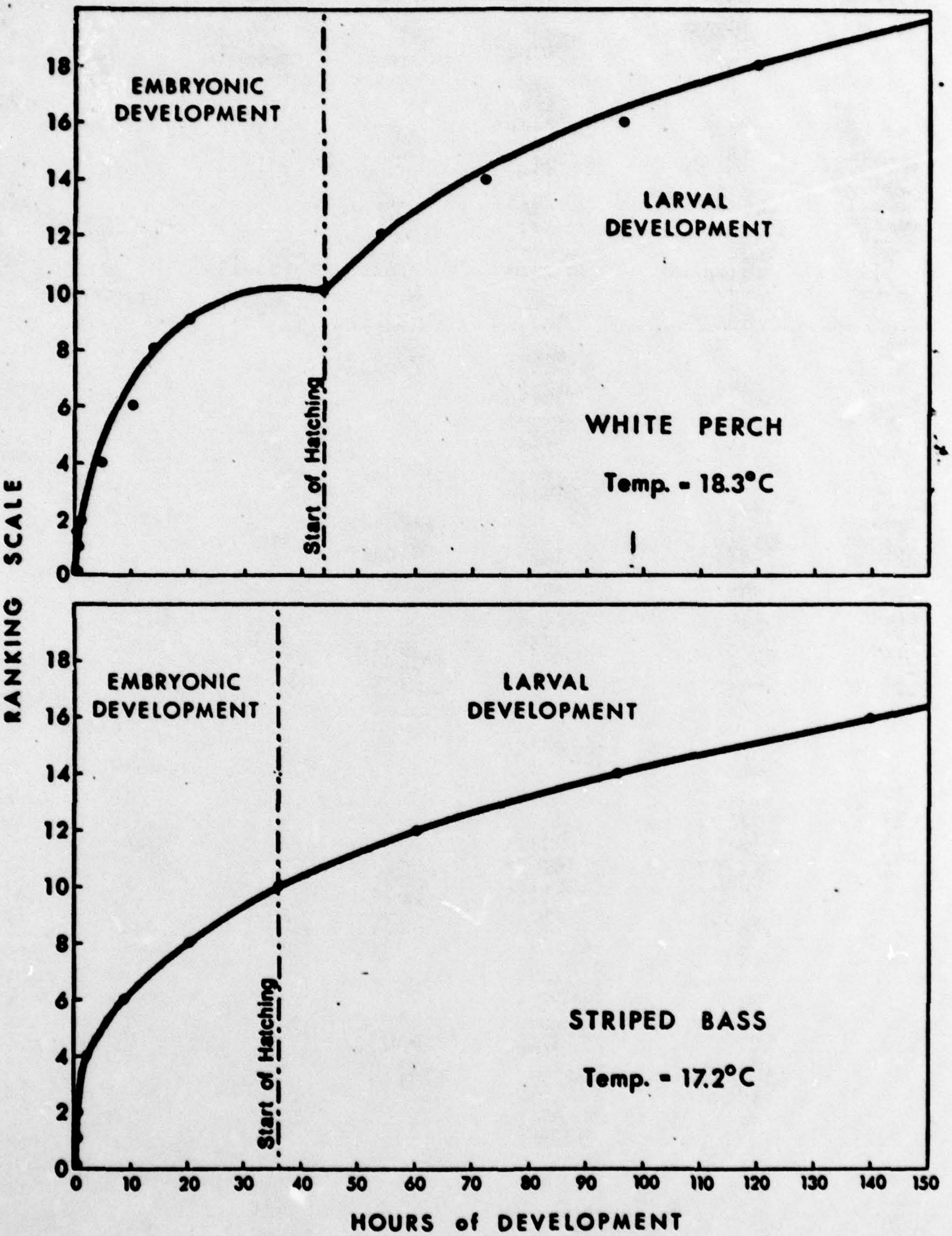

A-0
B-1
C-2
D-4
E-6
F-8
G-10
H-12
I-14
J-16
K-18
L-30

Fig. 5. The relationship of embryonic and larval development at specified temperatures to the ranking scales employed for striped bass and white perch eggs and larvae. The data for making these figures comes from Mansueti (1958, 1964). For descriptions of each rank for striped bass and white perch, see Table 1 and 2.



EMBRYONIC DEVELOPMENT
Start of Hatching
LARVAL DEVELOPMENT
WHITE PERCH
Temp. = 18.3°C
EMBRYONIC DEVELOPMENT
LARVAL DEVELOPMENT
Start of Hatching
STRIPED BASS
Temp. = 17.2°C
RANKING SCALE
HOURS of DEVELOPMENT
0
2
4
6
8
10
12
14
16
18
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150

Fig. 6. The effect of salinity on the ranked development/day of white perch eggs and larvae. Seven levels of salinity were tested.

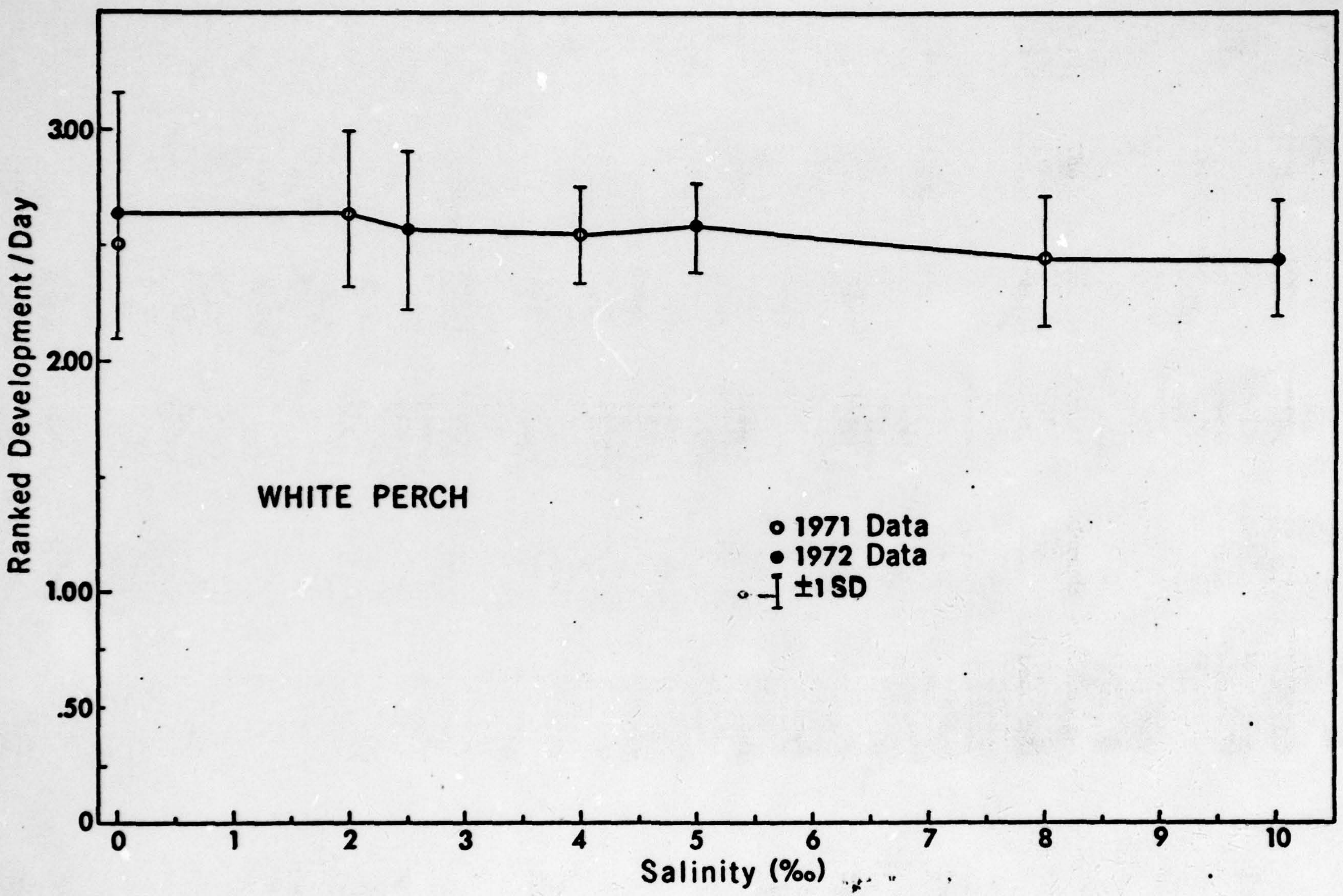

Ranked Development / Day
3.00
2.00
1.00
.50
0
0
1
2
3
4
5
6
7
8
9
10
Salinity (‰)
WHITE PERCH
1971 Data
1972 Data
±1 SD

Fig. 7. The effect of temperature on the ranked development/day of white perch eggs. Eleven levels of temperature were tested.

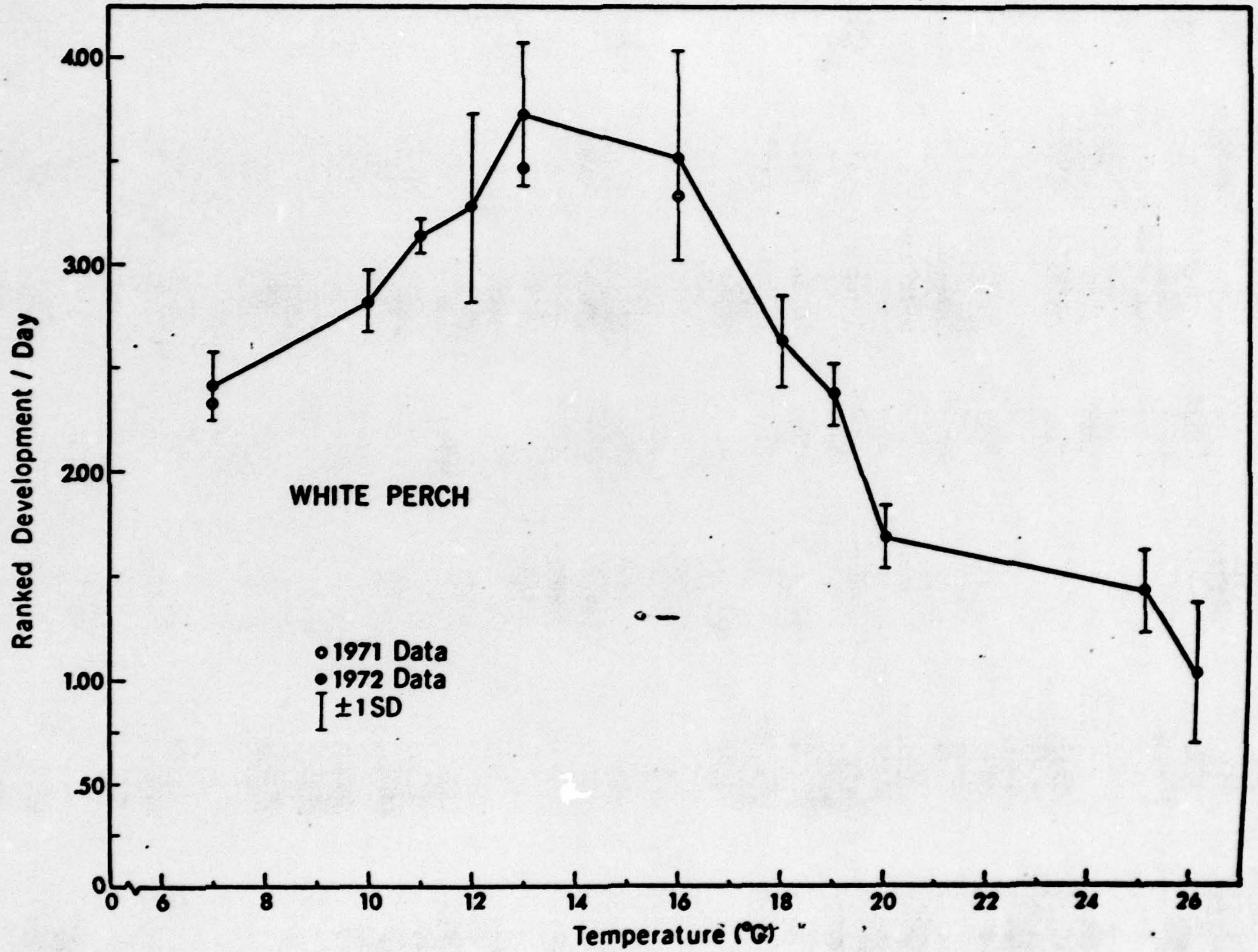

WHITE PERCH
o 1971 Data
• 1972 Data
±1 SD
Ranked Development / Day
4.00
3.00
2.00
1.00
.50
0
6
8
10
12
14
16
18
20
22
24
26
Temperature (°C)

Fig. 8. The effect of salinity on the ranked development/day of striped bass eggs. Four levels of salinity were tested. The point for the 1971 data at 0 ppt is discussed in the text.

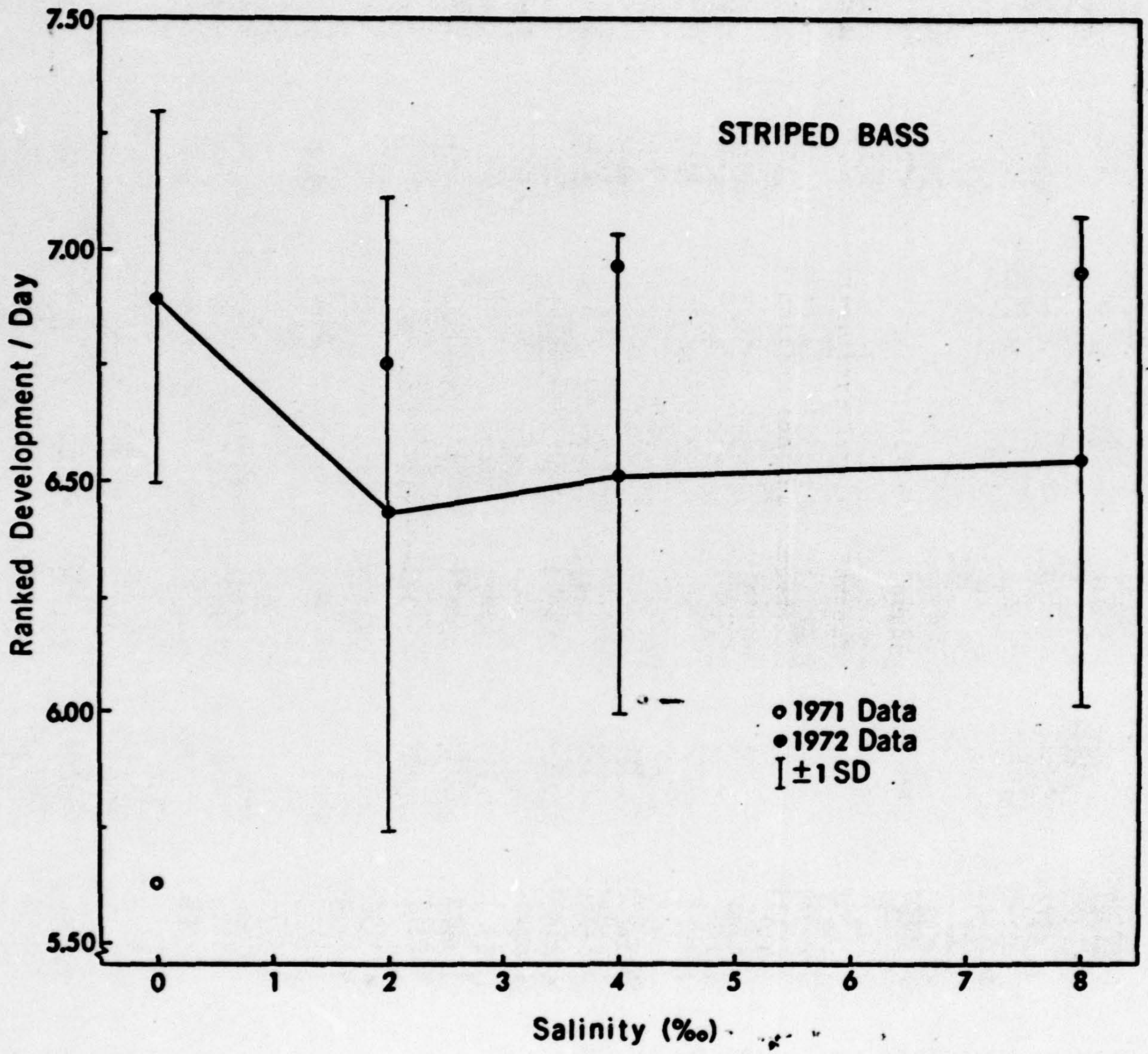

STRIPED BASS
Ranked Development / Day
7.50
7.00
6.50
6.00
5.50
0
1
2
3
4
5
6
7
8
Salinity (‰)
1971 Data
1972 Data
±1 SD

Fig. 9. The effect of salinity on the percent hatch and percent survival of striped bass larvae. Percent survival is based on the number of larvae hatched and the number alive at the end of one day.

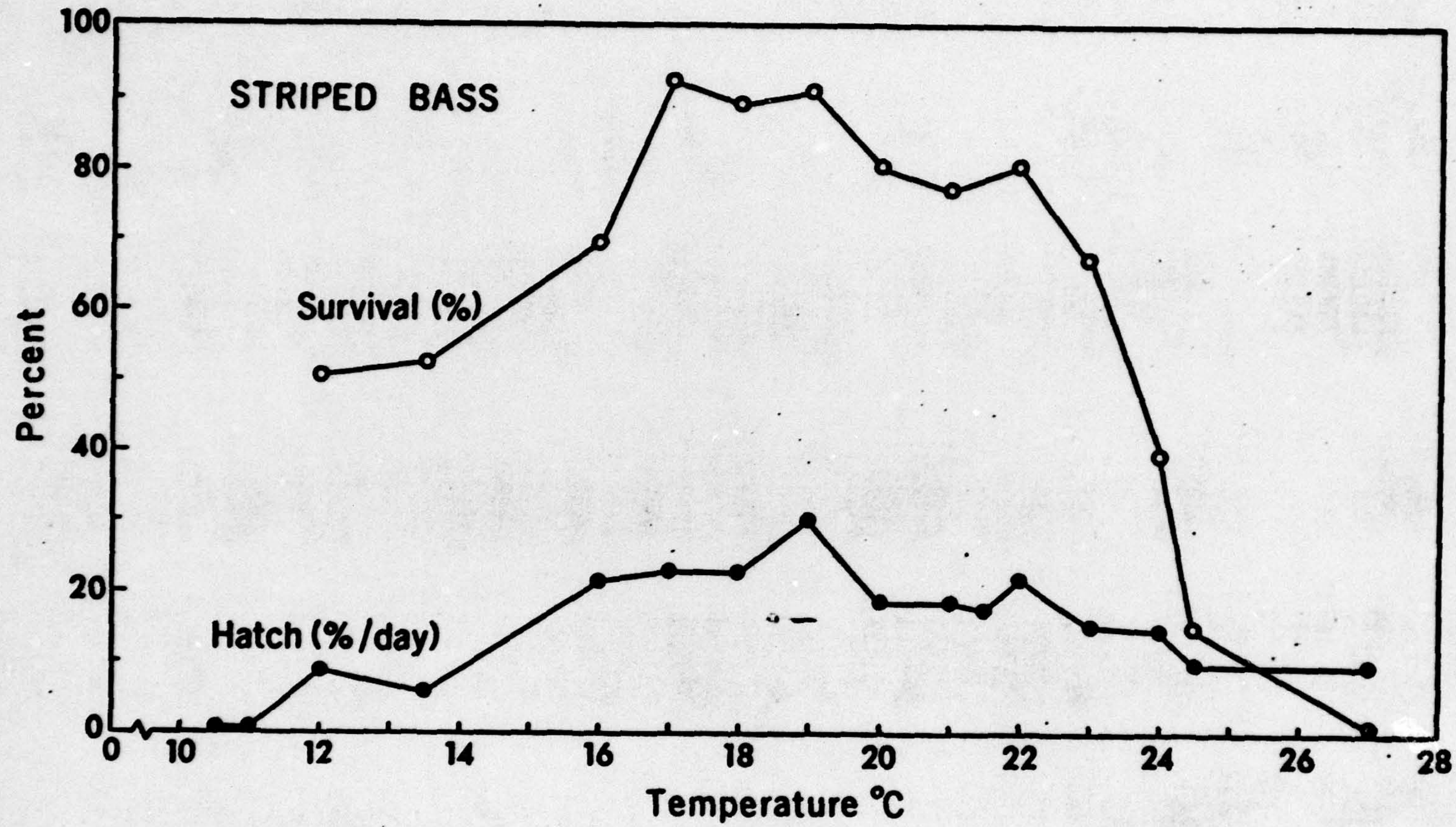

STRIPED BASS
Survival (%)
Hatch (%/day)
Percent
100
80
60
40
20
0
0
10
12
14
16
18
20
22
24
26
28
Temperature °C

Fig. 10. The effect of temperature on the ranked development/day of striped bass eggs. Sixteen levels of temperature were studied.

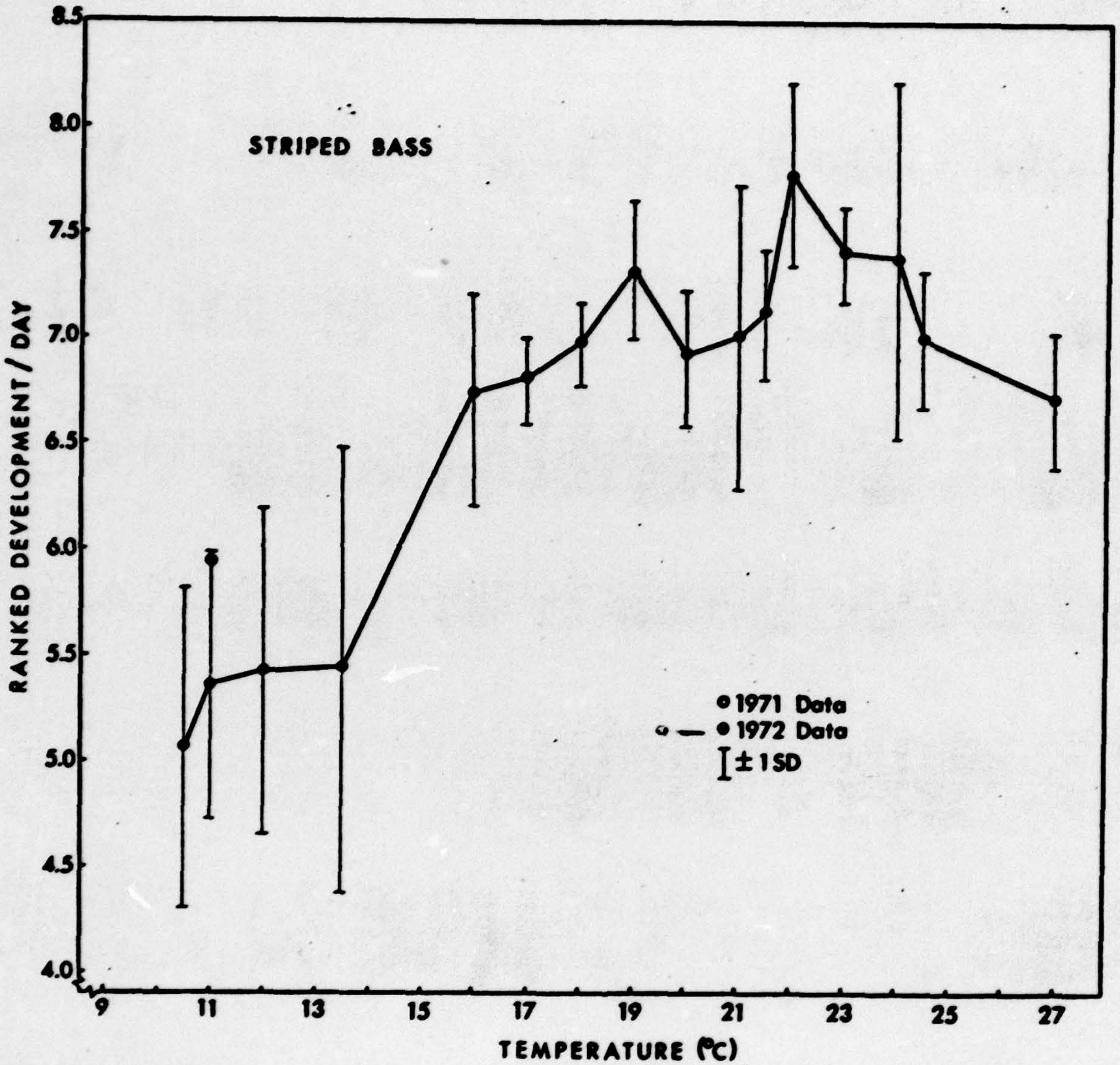
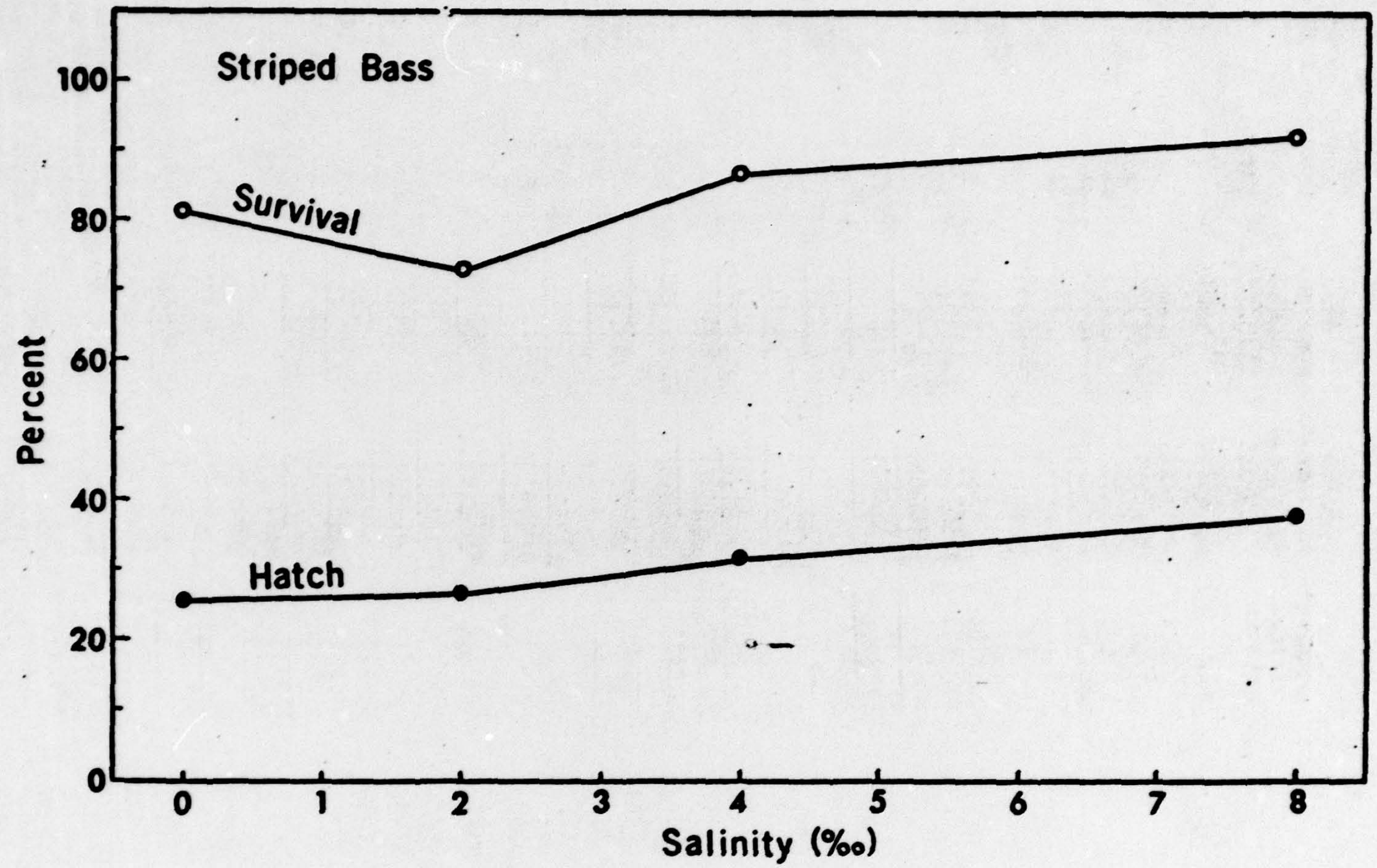

STRIPED BASS
RANKED DEVELOPMENT / DAY
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
9
11
13
15
17
19
21
23
25
27
TEMPERATURE (°C)
1971 Data
1972 Data
± 1SD

Fig. 11. The effect of temperature on striped bass hatch, as percent per day, and percent survival. Percent survival is based on the number of larvae hatched and the number alive at the end of one day.


Striped Bass
Survival
Hatch
Percent
100
80
60
40
20
0
0
1
2
3
4
5
6
7
8
Salinity (‰)